Summary of NRCS Technical Release 55
Urban Hydrology for Small Watersheds

(1986 version download - http://www.wcc.nrcs.usda.gov/water/quality/common/tr55/tr55.html)

I. USES

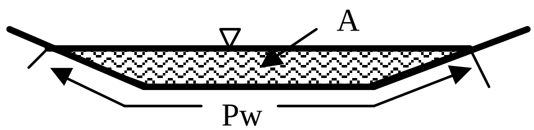
1) Estimate stormwater runoff volume and peak rates of discharge from urban or rural watersheds *(up to a 10 hour Tc)*;
2) Calculate storage volumes for detention basins and other flood routing applications; and
3) Create flow hydrographs *(Tabular method only)*.

II. DEFINITIONS

1) Surface Runoff (Q) - the depth (in inches) of excess water that runs off the landscape for a given total rainfall depth (See Table 2-1).
2) Runoff Curve Number (RCN) - a unitless number assigned to the landscape to estimate surface runoff **depth** (Q) for a given rain event. The higher the RCN the more runoff. (Hint: Think of it as a "percent of runoff"). Higher RCN's are given for landscapes with more impervious cover, surface soils with high clay content or lands with low soil cover. (See Table 2).
3) Hydrologic Soil Group (HSG) - a classification of soil (A-D) that indicates the rate of infiltration obtained for bare soil after prolonged wetting. It is primarily determined by the texture of the surface soil. (see Soil Survey)
   - A - Sandy loam surface soil/high infiltration/low runoff – common in central plains of WI and in local outwash plains.
   - B - Silt loam surface soil - most common in SE WI
   - C - Clay loam surface soil/low infiltration/high runoff - common in eastern part of SE WI
   - D - Usually low-lying areas/high water table/organic surface soils. Very low infiltration unless tiled. (If tiled, it may be assigned a B rating)
4) Connected Impervious Areas - where runoff from an impervious area flows directly into the drainage system or travels as shallow concentrated flow over a pervious area and then into a drainage system.
5) Unconnected Impervious Areas - where runoff from impervious areas is spread over a pervious area as sheet flow.
6) Initial Abstraction (Ia) - a number correlated with soil and cover parameters to include all losses before runoff begins. It includes water retention in surface depressions, water interception by vegetation and water lost to evaporation and infiltration.
7) Flow Length (l) - the longest flow path in the watershed from the watershed divide to the outlet. Used only in the Graphical Method.
8) Peak Discharge (q) - the peak **rate** of runoff (in cubic feet per second or cfs) from a drainage area for a given rainfall event. In TR-55, 24-hour rainfall *durations* are used because they have the most available data nationally. Rainfall *frequencies* or *return intervals* range from 1 to 100 years. (ex: 2-year/24-hour event, 10-year/24-hour event)
9) Time of Concentration (Tc) - the time it takes surface runoff to travel from the most distant point of the watershed or subarea to the outlet (Worksheet 3).
10) Travel Time (Tt) - the time it takes surface runoff to travel from one location to another within a watershed (Worksheet 3). Tt has two different applications:
    - In both the Graphical and Tabular methods, Tt is calculated for each flow type that exists (sheet, shallow concentrated, channel) along the Tc flow path. The summation of the Tt values equals the Tc for that watershed or subwatershed.
    - In the Tabular Method, Tt is also calculated to represent the time it takes upstream runoff to travel *through* a subarea in channel flow condition (see figure on page 5-4).

11) Cross-Sectional Flow Area (A) - the cross-sectional area (in sq. ft.) of a flow channel at design peak flow depth. Used in Manning's Formula to determine Tc or Tt.

12) Wetted Perimeter (Pw) - the cross-sectional distance of a channel (bottom width & side slopes) at design peak flow depth. Used in Manning's Formula to determine Tc/Tt.



12) Hydraulic Radius (Rh) - A/Pw (in feet). Used in Manning's Formula to determine Tc/Tt.

13) Hydrograph - the plotting of flow data with time intervals to determine time of peak flows for individual watersheds. A *composite hydrograph* can be created by combining (summing) this data for subwatersheds within a given drainage basin to determine peak flow times and volumes for that basin.

III. STEPS FOR DETERMINING PEAK FLOWS:

1) Delineate watershed boundary, major flow paths and land use/management areas on a scaled map.

2) Determine if watershed needs to be divided into subareas (subwatersheds).
   - Subareas are needed if conditions change significantly which affect runoff depth or timing of peak flows - such as widely differing RCN's or slopes, or more than one main channel exists with widely varying branches (in length or flow path type).
   - Tabular Hydrograph method must be used if subareas are delineated or if a hydrograph is needed.

3) Measure each land use/management area and calculate Runoff Curve Number (RCN) and total runoff (Q) using worksheet 2 and table 2. Do this for each subarea, if applicable.
   - To give credit for grass swales, separate the road and right-of-way in RCN calculations.
   - For urban uses, make sure assumptions are correct for impervious areas (Table 2-2a).
   - Require the consistent use of a given RCN for "before" conditions on converted cropland (see DNR standards).

4) Calculate Time of Concentration (Tc) and Travel Time (Tt), if applicable, using worksheet 3 (Also see figure 1-1 flowchart).
   - If using Graphical Peak Discharge Method (no subareas) then you will only calculate one Tc.
   - Tc is based on a single flow path or reach (the longest one in the watershed). A reach can be divided up into several segments if conditions change significantly (flow type, slope, surface condition, etc.). Never add travel times for different reaches to calculate one Tc.
   - Sheet flow cannot occur for more than 300 ft. for a reach.
   - If using the Tabular Hydrograph Method (with subareas) then you will need to compute Tc for each subarea.
   - If one or more subareas flows through another, calculate Tt through each subarea (enter on Worksheet 5a).
   - Tc will generally be reduced after urbanization, thus increasing peak flows. However, with grass swales and roads built along contours it may actually have the opposite effect.
   - Since velocity calculations are necessary for all open channels, use same data from Manning's Formula in Tc calculations for channel flow.

3) Complete Peak Flow Calculation using one of two methods:

A) Graphical Method (Worksheet 4)

- Use rainfall distribution type II.
- Add pond and swamp factor (Table 4-2) if internally drained areas are scattered in watershed but not in the Tc flow path.

B) Tabular Method (Worksheet 5a and 5b - use Computer!)

- Complete basic watershed data for each subarea (Worksheet 5a).
- Composite hydrograph is created by summing flow values for each subarea at selected time intervals.
- Peak flow rate and timing for the entire watershed is determined by the highest summed values.

IV. FLOW ROUTING FOR RETENTION / DETENTION FACILITIES

Definitions for this Section:

1) Detention - the temporary backup/storage of runoff water in a controlled area (pond/basin) in order to retard discharge *rates* during peak flows.
2) Storage Volume (Vs) - the minimum volume required in the pond/basin to retard peak flows for the design storm event. Standard unit is acre-feet. Measured as the water volume available between the elevations of the basin bottom (or permanent pool elevation) and the emergency spillway.
3) Runoff Volume (Vr) - the total volume of runoff from the watershed for a given storm event (see Worksheet 2). It is equal to Q (inches) * Watershed Area (acres) / 12 (in./ft.) = Acre-Feet.
4) Peak Outflow (qo) - is the design outflow rate of the retention/detention facility. It is usually specified by ordinance requirements (example: pre-development peak flows for 2-yr. 24-hour storm events).
5) Peak Inflow (qi) - is the peak rate of flow entering the retention/detention facility from the watershed under planned (developed) conditions.

Steps in Sizing a Retention / Detention Facility (Determining Vr Needed):

1) Calculate qo/qi ratio.

2) Determine Vs/Vr ratio from figure 6-la.

3) Solve for Vs where : Vs = V r * (Vs/Vr)

Notes:

- Primary outlet needs to be designed to carry the qo peak flow
- Emergency spillway should carry peak flows from a 100-year, 24-hour
- Multiple-stage outflow devices can also be designed with this method (i.e. control peak outflows for 2-yr. and 25-yr., 24 hour storms). The following apply:
  - Each stage requires a design storm and a computation of the storage required for it.
  - The discharge of the upper stage(s) must include the discharge of the lower stage(s).
- For temporary sediment basins (during construction) the DNR standards dictate this (surface area and min. depth). You need to solve for qo (outlet size) based on the three day draw—down requirement (see Exhibit 8-5).